MARTIAN FLUVIAL-THERMAL EROSION : EXPERIMENTAL CONTROL OF THE MODEL. F. Costard, J. Aguirre-Puente, N. Makhloufi and R. Greeley[2]. Centre de Géomorphologie, CNRS, ER 109, rue des Tilleuls, 14000 Caen, France. [2] Arizona State University, Dept. of Geology, Tempe, Arizona 85287-1404.

Wide outflow channels occur both in Siberia and on the planet Mars. In Siberia, thermal erosion results from ground thawing produced by the heat transfer from the water flow to the frozen ground. A similar process could explaine the Martian owtflow channel morphology. In order to estimate the thermal erosion efficiency, we have utilized a one-dimensional model. A first test of this model is a comparison of results with measurements conducted on Siberian rivers. In addition, the theoretical model was tested with experiments using a hydraulic channel that allows measurement of the propagation of the thawing line and the thermal erosion rate in simulated Martian ground ice that is undergoing the effects of a warm water flow.

Introduction. The presence of runoff and outflow channels (1) suggests that liquid water exists in the megaregolith throughout most of the Martian history (2, 3). Different interpretations of these outflow channels are proposed (figure 1). Lucchitta (4) considers them as possible glacial valleys and Komar (5) thinks they have similarities with submarine rivers. Carr (6) suggests that these valleys were formed by sudden release of water from confined aquifers producing catastrophic floods, and Baker (1) considers them as highly turbulent catastrophic floods. Costard (7) first suggested that thermal erosion was likely in the outflow channels because of the presence of ground-ice and the large scale of channels. Some of the channels where thermal erosion occured are as old as 3.5 aeons. We consider this typical situation on Mars, in which ground ice coexists with liquid water near the surface, as representing an interesting case which need particular attention. Here, the thermal erosion is considered to result from thawing of the ground by heat exchange between the water flow and the frozen ground, followed by an immediate transport of unfrozen sediments. In Arctic regions, the strong flow of water during the spring and summer annually interact with ground-ice and other frozen obstacles leads to bank recession of 19 to 24 m$\times$ year^{-1} (8,9).

Ablation model and its application to the experimentation. In 1994, a mathematical thermal model was proposed (10); it involves a constant heat flux in association with an immediate removal of thawed sediments. This is an ablation model. For its application, estimations of the heat transfer coefficient and heat flux are necessary. Determination of these coefficients needs the calculation of dimensionless numbers (Reynolds, Prandtl, Nusselt), and the consideration of turbulent regime of the flow.

To test our theoretical fluvial-thermal model (ablation model), an experimental hydraulic device was built. The frozen sample, in thermal contact with the water during the experiments undergoes a strong thermal action. In order to monitor the ablation conditions, the ground ice sample is located in the upper level of a rectangular cross-section tube 2 meters long by 20 cm across. The sample is fixed in the main axis of the hydraulic channel on a mounting support and can slide along a linear steel track.

The channel discharge was calculated to produce a turbulent regime and to ensure the immediate removal of the thawed sediments. Temperature measurements are obtained with thermocouples.

The assembled apparatus was placed in a "cold" room in which temperature was maintained at regulated value ($\pm$ 0.5 K) both above or below the freezing point of water. The loss rate of the frozen sample during the experiment was controlled by a laser beam connected to a data acquisition system. This laser system measured the thermal erosion and controled the vertical sliding of the frozen sample.

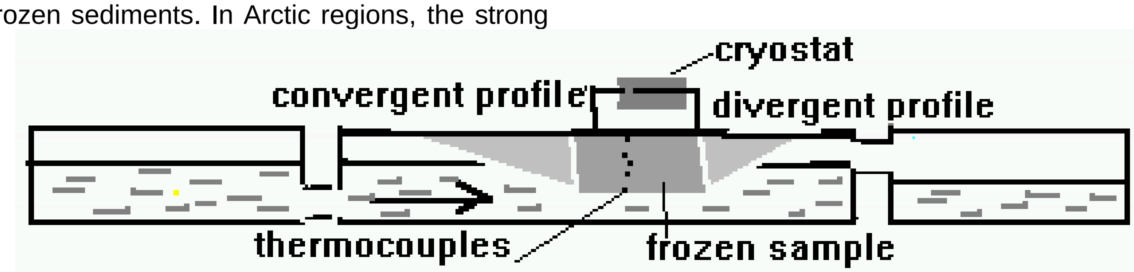

Figure 1: Schematic view of the simulation.

The turbulent conditions is determined by laboratory simulation with the help of the tube Reynolds Number formula: $Nu = 1.343 Pr^{1/3} Re^{0.491}$. Both for the ablation model and for the laboratory simulation, the following parameters were considered : water temperature : T_W = 0°C to 5°C ; ground ice temperature : T_i = -5°C to -20°C ; hydraulic diameter : D_h = 0.114 m ; discharge rate : Q = 1.48 10^{-3} to 3.08 10^{-3} $m^3 s^{-1}$; Reynolds number : 6904 to 14484 ; Nusselt number : Nu = 217.46 to 320.87 ; thermal conductivity of the frozen soil : k = 0.57 W $m^{-1} K^{-1}$; heat transfer coefficient : h = 1087.31 to 1604.7 W $m^{-2} K^{-1}$.

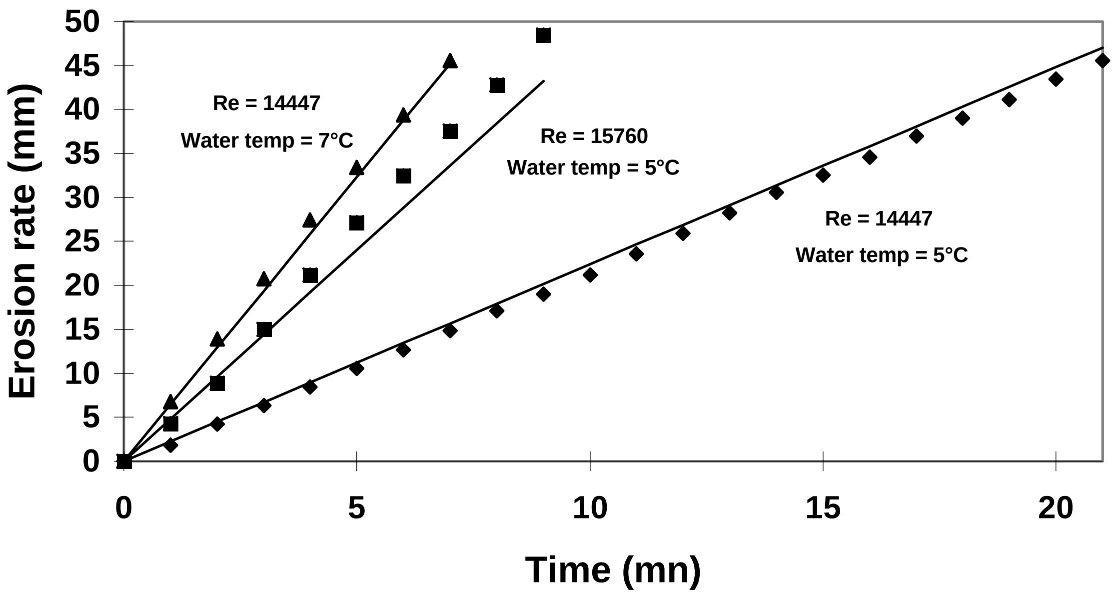

Figure 2: Rate of thermal erosion vs time. ◆ ■ : laboratory simulation; — : mathematical model

Conclusions: Calculations as well as laboratory simulations show that even a small value of ΔT = 5 K (temperature of the water minus temperature of the ground surface) produces active thermal erosion. Measurements with various ground ice samples, discharge rates and temperatures are proposed. Results from experiments are in good agreement with theoretical estimates (ablation model). Figure 2 shows hierarchy of parameters in term of efficiency of fluvial thermal erosion, in which water temperature seems to be the most important and ground ice temperature the less important.

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